PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2000-091881

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(21)Application number : 10-253597

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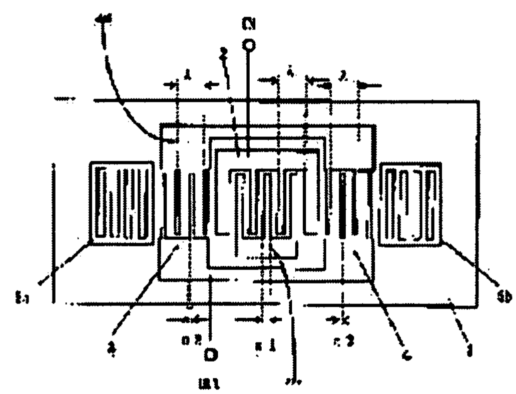
(71)Applicant : TOYO COMMUN EQUIP CO LTD

(72)Inventor : OGAWA YUJI

(54) CASCADE CONNECTING DOUBLE MODE SAW FILTER

(57)Abstract:

PROBLEM TO BE SOLVED: To obtain excellent attenuation in a preventing area on a high frequency side in the neighborhood of a pass band by arranging IDT electrodes and grating reflectors along the propagating direction of a surface wave on a piezoelectric substrate and differentiating the exciting frequency of the IDT electrode on an inputting side and that of the IDT electrode on an outputting side.



SOLUTION: Three IDT electrodes 2 to 4 are closely arranged along the propagating direction of the surface wave on the main surface of the piezoelectric substrate 1 and the grating reflectors 5a and 5b are arranged on both sides of these. The electrodes 2 to 4 are formed of a pair of interdigital electrodes with plural electrode fingers respectively inserting each other, one interdigital electrode of the electrode 2 is connected with an input terminal IN and the other interdigital electrode is grounded. On the other hand, respectively one interdigital electrodes of the electrodes 3, 4 are connected with each other and connected to an output terminal OUT and the other interdigital electrodes are connected with each other and grounded in this structure. Then, the exciting frequency of the IDT electrode on the inputting side and that of the IDT electrode on the outputting side are made different from each other.

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PROBLEM TO BE SOLVED: To obtain excellent attenuation in a preventing area on a high frequency side in the neighborhood of a pass band by arranging IDT electrodes and grating reflectors along the propagating direction of a surface wave on a piezoelectric substrate and differentiating the exciting frequency of the IDT electrode on an inputting side and that of the IDT electrode on an outputting side.

SOLUTION: Three IDT electrodes 2 to 4 are closely arranged along the propagating direction of the surface wave on the main surface of the piezoelectric substrate 1 and the grating reflectors 5a and 5b are arranged on both sides of these. The electrodes 2 to 4 are formed of a pair of interdigital electrodes with plural electrode fingers respectively inserting each other, one interdigital electrode of the electrode 2 is connected with an input terminal IN and the other interdigital electrode is grounded. On the other hand, respectively one interdigital

electrodes of the electrodes 3, 4 are connected with each other and connected to an output terminal OUT and the other interdigital electrodes are connected with each other and grounded in this structure. Then, the exciting frequency of the IDT electrode on the inputting side and that of the IDT electrode on the outputting side are made different from each other.

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[Date of extinction of right]	

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CLAIMS

[Claim(s)]

[Claim 1] The vertical joint dual mode SAW filter characterized by changing the exciting frequency of an input-side IDT electrode, and the exciting frequency of an output side IDT electrode in the vertical joint dual mode SAW filter which arranges and constituted the grating reflector along the propagation direction of a surface wave at the both sides of two or more IDT electrodes and this IDT electrode on the piezo-electric substrate.

[Claim 2] The vertical joint dual mode SAW filter according to claim 1 characterized by changing electrode finger line pulse duty factor eta1' of an input-side IDT electrode, and line pulse duty factor eta2' of an output side IDT electrode.

[Claim 3] the electrode finger of an input-side IDT electrode -- a logarithm -- N1 and a line pulse duty factor -- eta1' -- carrying out -- the electrode finger of an output side IDT electrode -- the ratio of eta1' and eta2' in the case of N1>N2, when a logarithm is made to N2 and a line pulse duty factor is made into eta2' In the case of 0.2<eta2'/eta1' <1-N1<N2 Claim 1 characterized by being referred to as 0.2<eta1'/eta2'<1, or vertical joint dual mode SAW filter given in two.

[Claim 4] The vertical joint dual mode SAW filter according to claim 1 characterized by changing the electrode period lambda 1 of an input-side IDT electrode, and the electrode period lambda 2 of an output side IDT electrode.

[Claim 5] the electrode finger of an input-side IDT electrode -- a logarithm -- N1 and an electrode period -- lambda 1 -- carrying out -- the electrode finger of an output side IDT electrode -- the ratio of lambda1 and lambda2 in the case of

N1>N2, when a logarithm is set to N2 and an electrode period is set to lambda 2 In the case of 0.960<lambda2/lambda 1< 1.000-N1<N2 Claim 1 characterized by being referred to as 0.960<lambda1/lambda2<1.000, or vertical joint dual mode SAW filter given in four.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] Especially this invention relates to the vertical joint dual mode SAW filter which has improved the inhibition zone magnitude of attenuation by the side of the high region near the passband about a vertical joint dual mode SAW filter.

[0002]

[Description of the Prior Art] In recent years, especially many SAW devices to a cellular phone etc. are used from having the description which was used widely and was [nature / high performance, small, / mass production] excellent in the communication link field. Drawing 7 is the typical top view of the electrode pattern in which the configuration of the conventional primary 3rd [-] length joint dual

mode SAW filter (a dual mode SAW filter is called hereafter) is shown, and it arranges Reflectors 15a and 15b in these both sides while it carries out contiguity arrangement of the three IDT electrodes 12, 13, and 14 along the propagation direction of a surface wave on the principal plane of the piezo-electric substrate 11. The IDT electrodes 12, 13, and 14 are constituted by the tandem type electrode of the couple which has two or more electrode fingers put mutually in between, respectively, they are the IDT electrodes 12, while go away, connect a form electrode to an input terminal IN, and ground the tandem type electrode of another side. On the other hand, it is the IDT electrodes 13 and 14, while by going away, the tandem type electrode of another side is connected mutually, and a form electrode grounds it while connecting mutually and connecting with an output terminal OUT.

[0003] The actuation of a dual mode SAW filter shown in drawing 7 Two or more surface waves excited with the IDT electrodes 12, 13, and 14 as everyone knows Reflector 15a, Since it is shut up between 15b, an acoustic turnover is carried out among the IDT electrodes 12, 13, and 14 and two vertical resonance modes, the primary order [3rd], are excited by stress as a result, it operates as a dual mode SAW filter using these two modes by giving suitable termination. In addition, the pass band width of this dual mode SAW filter of being decided by the delta frequency of primary resonance mode and the 3rd resonance mode is well known.

[0004] Drawing 8 shows the filtering property of the dual mode SAW filter of the two-step cascade connection shown in drawing 7 . a piezo-electric substrate -- the 36 degreeY cut X propagation $LiTaO_3$ -- using -- the electrode of the input IDT electrode 12 -- 20.5 pairs of logarithms N1 the electrode of output electrodes 13 and 14 -- a logarithm N2 -- respectively -- 11.5 pairs and grating 15a -- 250 and electrode layer thickness of an aluminum alloy are set to 6%lambda (wavelength of the surface wave by which lambda is excited) for the number of 15b, respectively. The pitch of said electrode can be set up so that the center frequency of a filter may be set to 900MHz, and 4% of fractional bandwidths and

a broadband band pass filter can be obtained.

[0005]

[Problem(s) to be Solved by the Invention] However, center frequency with a pass band width of 1dB is set to f0 so that clearly from the filtering property of drawing 8 . The magnitude of attenuation of frequency-domain f0**(45**12.5) MHz of a dual mode SAW filter As opposed to about 40dB being obtained in f0-(45**12.5) MHz by the side of low frequency In the frequency domain A of f0+(45**12.5) MHz by the side of a RF, only about 20dB was obtained but there was a problem that the specification (25dB or more) required of the latest digital cellular phone could not be satisfied. It is made in order that this invention may solve the above-mentioned problem, and while being a broadband, it aims at offering the dual mode SAW filter which has improved the inhibition zone magnitude of attenuation by the side of the RF near [above-mentioned] the passband.

[0006]

[Means for Solving the Problem] Invention of the vertical joint dual mode SAW applied to this invention in order to attain the above-mentioned object according to claim 1 is a vertical joint dual mode SAW filter characterized by changing the exciting frequency of an input-side IDT electrode, and the exciting frequency of an output side IDT electrode in the vertical joint dual mode SAW filter which arranges and constituted the grating reflector along the propagation direction of a surface wave at the both sides of two or more IDT electrodes and this IDT electrode on the piezo-electric substrate. Invention according to claim 2 is a vertical joint dual mode SAW filter according to claim 1 characterized by changing electrode finger line pulse duty factor eta1' of an input-side IDT electrode, and line pulse duty factor eta2' of an output side IDT electrode. invention according to claim 3 -- the electrode finger of an input-side IDT electrode -- a logarithm -- N1 and a line pulse duty factor -- eta1' -- carrying out -- the electrode finger of an output side IDT electrode -- the ratio of eta1' and eta2' in the case of N1>N2, when a logarithm is made to N2 and a line pulse duty

factor is made into eta2' In the case of 0.2<eta2'/eta1' <1-N1<N2 They are claim 1 characterized by being referred to as 0.2<eta1'/eta2'<1, or a vertical joint dual mode SAW filter given in two. Invention according to claim 4 is a vertical joint dual mode SAW filter according to claim 1 characterized by changing the electrode period lambda 1 of an input-side IDT electrode, and the electrode period lambda 2 of an output side IDT electrode. invention according to claim 5 -- the electrode finger of an input-side IDT electrode -- a logarithm -- N1 and an electrode period -- lambda 1 -- carrying out -- the electrode finger of an output side IDT electrode -- the ratio of lambda1 and lambda2 in the case of N1>N2, when a logarithm is set to N2 and an electrode period is set to lambda 2 In the case of 0.960<lambda2/lambda 1< 1.000-N1<N2 They are claim 1 characterized by being referred to as 0.960<lambda1/lambda2<1.000, or a vertical joint dual mode SAW filter given in four.

[0007]

[Embodiment of the Invention] This invention is explained to a detail based on the gestalt of operation shown in the drawing below. the top view showing the configuration of the dual mode SAW filter which drawing 1 requires for this invention -- it is -- the principal plane top of the piezo-electric substrate 1 -- the propagation direction of a surface wave -- meeting -- three IDT electrodes 2 and 3 -- while carrying out 4 contiguity arrangement, the grating reflectors 5a and 5b are arranged in these both sides. The IDT electrodes 2, 3, and 4 are constituted by the tandem type electrode of the couple which has two or more electrode fingers put mutually in between, respectively, they are the IDT electrodes 2, while go away, connect a form electrode to an input terminal IN, and ground the tandem type electrode of another side. While being the IDT electrodes 3 and 4, while going away, connecting the form electrode of each other on the other hand and connecting with an output terminal OUT, the tandem type electrode of another side is made into the structure which connects mutually and is grounded.

[0008] The description of this invention is to set up more broadly than the electrode digit eta 2 of the IDT electrodes 3 and 4 the electrode digit eta 1 of the

IDT electrode 2 while making almost the same the electrode period of the IDT electrodes 2, 3, and 4. drawing 1 -- the electrode of the IDT electrode 2 -- a logarithm N1 -- the electrode of the IDT electrodes 3 and 4 -- it is the set-up example.

[0009] the electrode of a normal mold IDT electrode -- if N and its electrode period are set to lambda and an scaling frequency is set to omega (here omega0=2pi V/lambda = = (omega-omega 0) / omega 0, 2 pi f0 and V rate of a surface wave) for a logarithm -- the frequency characteristics of an IDT electrode -- sin (Npiomega)/sin (piomega)

it comes out and expresses -- having -- an attenuation pole -- every 1-/N -- appearing -- the bandwidth -- a logarithm -- it is known that it is in inverse proportion to N. The frequency characteristics of this IDT electrode repeated periodically are hereafter called transversal property. The transversal property of the I/O IDT electrodes 2-4 appears, and, as for the frequency characteristics outside the passband of a dual mode SAW filter, the periodic attenuation pole by the transversal property appears in an inhibition zone. Among these, if it can be made in agreement with the frequency domain A of f0+(45**12.5) MHz which shows the attenuation pole by the side of the RF of a main lobe to drawing 8 , it will be imagined as that by which the improvement of the magnitude of attenuation of this frequency domain is aimed at.

[0010] the conventional dual mode SAW filter shows to drawing 7 -- as -- the electrode finger of the input IDT electrode 12 -- a logarithm N1 -- the electrode finger of the output IDT electrodes 13 and 14 -- while setting up more mostly than a logarithm N2, it is common to set up the exciting frequency of the I/O IDT electrodes 12, 13, and 14 as it is almost the same. Therefore, the main lobe M1 of the input IDT electrode 12 by the transversal property and the main lobe M2 of the output IDT electrodes 13 and 14 become almost the same [the center frequency of each bandwidth], as shown in drawing 2 (a). however, the electrode of the IDT electrode 12 and the IDT electrodes 13 and 14 -- by setting a logarithm to N1>N2, the bandwidth of each main lobe differs, as shown in

drawing 2 (a). That is, compared with the bandwidth of a main lobe M2, the bandwidth of a main lobe M1 serves as ******. Here, P1 and P2 shall point out the attenuation pole by the side of the RF of main lobes M1 and M2, respectively. Since the passband of a dual mode SAW filter is located in the main lobe M1 of the I/O IDT electrodes 12-14, and M2, the attenuation poles P1 and P2 of a main lobe will appear in the outside of a frequency domain A. Then, various means for controlling the location of the attenuation poles P1 and P2 of a main lobe, and making it in agreement with the frequency domain A which should be improved were examined.

[0011] Consequently, the above-mentioned frequency domain A found that it was impossible to arrange the attenuation poles P1 and P2 of a main lobe only by changing the exciting frequency of an I/O IDT electrode simply. although this reason is located in the main lobe of the transversal property that the I/O IDT electrodes 12-14 present the passband of a dual mode SAW filter -- the electrode of the input IDT electrode 12 -- a logarithm N1 -- each electrode of the output IDT electrodes 13 and 14 -- since it has set up more mostly than a logarithm N2, it will be formed inside the bandwidth of the main lobe M1 with the narrow bandwidth formed with the input IDT electrode 12.

[0012] The attenuation poles P1 and P2 of a main lobe cannot be made in agreement with a frequency domain A with a means to arrange the main lobe M1 with narrow bandwidth from the main lobe M2 with wide bandwidth to a high frequency side by the above reason as shown in drawing 2 (b). Then, it found out that it was possible to make it in agreement with the frequency domain A where a dual mode SAW filter should improve the attenuation pole P1 which appears in the RF side of a main lobe M1 by arranging the main lobe M1 with narrow bandwidth from the main lobe M2 with wide bandwidth to a low frequency side, as shown in drawing 2 (c).

[0013] First, the case where the exciting frequency of an IDT electrode is changed by changing an electrode pitch is examined. Drawing 3 is the dual mode SAW filter which changed each exciting frequency by seting constant the line

pulse duty factor of the IDT electrodes 6, 7, and 8, and changing mutually the IDT electrode 6, the IDT electrodes 7 and 8, and an electrode finger pitch. Two-step cascade connection of the dual mode SAW filter of drawing 3 is carried out, and the result of having asked for the magnitude of attenuation and electrode period ratio (lambda2/lambda1) relation to a frequency domain A by simulation is shown in drawing 4 . the range of an electrode period ratio (lambda2/lambda1) which the magnitude of attenuation in a frequency domain A can improve, maintaining a passband in the good condition so that clearly from drawing 4 -- the electrode finger of an input electrode -- a logarithm N1 -- the electrode finger of an output electrode -- case [than a logarithm N2] more -- 0.96 -- < -- it turned out that it is lambda2/lambda1<1.000.

[0014] Based on the above-mentioned result, the 36 degreeY cut X propagation LiTaO3 is used for a piezo-electric substrate. the electrode finger of the input IDT electrode 6 -- a logarithm N1 -- the electrode finger of 22.5 pairs and the output IDT electrodes 7 and 8 -- 12.5 pairs of logarithms N2, respectively 250 and the electrode layer thickness of an aluminum alloy for the number of the grating reflectors 9a and 9b 6%lambda, When the dual mode SAW filter which set as 0.980 the ratios lambda2/lambda1 of the electrode period lambda 2 of the output IDT electrodes 7 and 8 which receive input IDT electrode period lambda1 was constituted, it turned out that the magnitude of attenuation can improve about 8dB of the filtering property in the frequency domain of f0+(45**12.5) MHz. However, the differences of the above-mentioned electrode period are very few actually, and the effectiveness may fully be unable to be enjoyed according to the manufacture error by the present photolithography technique.

[0015] Then, we decided to examine a means to change an exciting frequency for IDT the same electrode period. There are an approach of changing the electrode layer thickness of an IDT electrode to the 1st, and a method of changing the line pulse duty factor (line width-of-face/(line width-of-face + tooth-space width of face)) of an IDT electrode finger to the 2nd. Although it is necessary to control to accuracy the IDT electrodes 2 and 3 which adjoin across

1-2-micrometer space on the same piezo-electric substrate, and the thickness of 4 by the former, with a current technique, manufacture variation is not so practical greatly as well as a production process becoming complicated. Then, how to change mutually the line width of face eta 1 of the IDT electrode 2 and the line width of face eta 2 of the IDT electrodes 3 and 4 as shown in drawing 1 was examined as a means to change an exciting frequency, without changing the electrode period of an I/O IDT electrode. Since it is the same electrode period, the ratio of the line width of face eta1 and eta2 is equal to the ratio of each line pulse duty factor eta1' and eta2'.

[0016] IDT -- an electrode -- two -- three -- four -- an electrode -- a period -- the same -- carrying out -- an input -- IDT -- an electrode -- two -- a line -- a pulse duty factor -- eta -- one -- ' -- an output -- IDT -- an electrode -- three -- four -- a line -- a pulse duty factor -- eta -- two -- ' -- mutual -- differing -- making -- things -- each -- an exciting frequency -- changing -- the dual mode -- an SAW filter -- having constituted -- an example -- drawing 1 -- it is . Drawing 5 is the result of asking for the relation between the magnitude of attenuation and a line pulse duty factor ratio (eta2'/eta1') by simulation in the frequency domain A of the filter which carried out two-step cascade connection of the dual mode SAW filter shown in drawing 1 (f0+(45**12.5) MHz). the ratio of the line pulse duty factor which the magnitude of attenuation can improve in the frequency domain A in drawing 8 while this had maintained the passband in the good condition -- eta2'/eta1' -- the electrode finger of an input electrode -- a logarithm N1 -- the electrode finger of an output electrode -- case [than a logarithm N2] more -- 0.2 -- < -- eta 2 -- '/eta1' -- it is shown that it should set up with <1.

[0017] Drawing 6 is drawing showing the filtering property of the filter constituted based on the above-mentioned examination result. a piezo-electric substrate -- the 36 degreeY cut X propagation LiTaO3 -- using -- the electrode finger of the input IDT electrode 2 -- 20.5 pairs of logarithms N1 the electrode finger of the output IDT electrodes 3 and 4 -- a logarithm N2 -- respectively -- 11.5 pairs and grating reflector 5a -- five -- b -- a number -- 250 -- a ** -- an aluminum alloy -- an

electrode layer -- thickness -- six -- % -- lambda -- an input -- IDT -- an electrode -- a line -- a pulse duty factor -- eta -- one -- ' -- receiving -- an output -- IDT -- an electrode -- a line -- a pulse duty factor -- eta -- two -- ' -- a ratio -- eta -- two -- ' -- /-- eta -- one -- ' -- 0.43 -- having set up -- ** -- the property of a case -- it is . In addition, the electrode finger pitch was set up so that a center of filter frequency might be set to 900MHz.

[0018] It turns out that about 10dB improves compared with the magnitude of attenuation of the conventional dual mode SAW filter which the magnitude of attenuation by the side of the RF near the passband (frequency domain A) indicated to drawing 8 was clear from drawing 6 . The demand of RF filter for cellular phones which needs to make the magnitude of attenuation near the passband steeper than this improvement can fully be filled now.

[0019] explanation of drawing 1 -- the electrode finger of the input IDT electrode 2 -- a logarithm N1 -- the electrode finger of the output IDT electrodes 3 and 4, although the example in the case of [than a logarithm N2] more was taken up conversely, the electrode finger of the input IDT electrode 2 -- a logarithm N1 -- the electrode finger of the output IDT electrodes 3 and 4 -- the case where will change a line pulse duty factor and the magnitude of attenuation in a frequency domain A will be improved if the case of being fewer than a logarithm N2 is examined -- a line pulse duty factor ratio -- 0.2 -- < -- eta1'/eta2' -- <1, then a good thing have been checked.

[0020] moreover -- the example of drawing 5 -- the electrode finger of the input IDT electrode 6 -- a logarithm N1 -- the electrode finger of the output IDT electrodes 7 and 8, although the case more than a logarithm N2 was explained conversely, the electrode finger of the input IDT electrode 6 -- a logarithm N1 -- the electrode finger of the output IDT electrodes 7 and 8 -- if the case of being fewer than a logarithm N2 is examined, for changing an electrode period and improving the magnitude of attenuation of a frequency domain A -- an electrode period ratio -- 0.96 -- < -- lambda1/lambda2<1.000, then a good thing were checked.

[0021] In addition, although the above explanation explained to the primary 3rd [-] length joint dual mode SAW filter which used three IDT electrodes, it is not necessary to say that it can apply if this invention is a dual mode SAW filter which is not limited only to this and has two or more IDT electrodes.
[0022] Furthermore, although explanation of this invention showed above the example which used the 36 degreeY cut X propagation LiTaO3 to the piezo-electric substrate, this invention is not limited only to this and can be applied to the vertical joint dual mode SAW filter using any piezo-electric substrates. For example, it is not necessary to say that it is applicable also to the piezoelectric material of 45-degreeX cut Z propagation Li2B 4O7, ST cut Xtal, the 42 degreeY cut X propagation LiTaO3, or 64 degreeY cut X propagation LiNbO3 grade.
[0023]
[Effect of the Invention] Since this invention was constituted as explained above, in a vertical joint dual mode SAW filter, about 10dB of magnitude of attenuation by the side of the RF near the passband can be improved now, and the effectiveness which was excellent when improving the engine performance, if the dual mode SAW filter of this invention is used for RF filters, such as a cellular phone, is expressed.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the top view showing the electrode configuration of the primary 3rd [-] length joint dual mode SAW filter concerning this invention.

[Drawing 2] (a), (b), and (c) are drawings explaining the frequency of a main lobe and the relation of a filter shape which an I/O IDT electrode presents.

[Drawing 3] It is the example of the primary 3rd [-] length joint dual mode SAW filter concerning this invention, and is the top view of the filter which changed and constituted the electrode period.

[Drawing 4] It is drawing showing the relation between the pitch ratio of an IDT electrode, and the magnitude of attenuation by the side of the RF near the passband.

[Drawing 5] It is drawing showing the relation between line pulse duty factor ratio lambda2'/lambda1' and the magnitude of attenuation near the pass band of a dual mode SAW filter.

[Drawing 6] It is the filtering property which asked for the dual mode SAW filter concerning this invention by simulation.

[Drawing 7] It is the top view showing the electrode configuration of the conventional primary 3rd [-] length joint dual mode SAW filter.

[Drawing 8] It is drawing showing the filter shape of the conventional primary 3rd [-] length joint dual mode SAW filter.

[Description of Notations]

1 .. Piezo-electric substrate

3, 4, 6, 7, 8 .. IDT electrode

5a, 5b, 9a, 9b .. Grating reflector

lambda1, lambda2 .. IDT electrode period

eta1, eta2 .. Line width of face

eta1', eta2' .. Line pulse duty factor

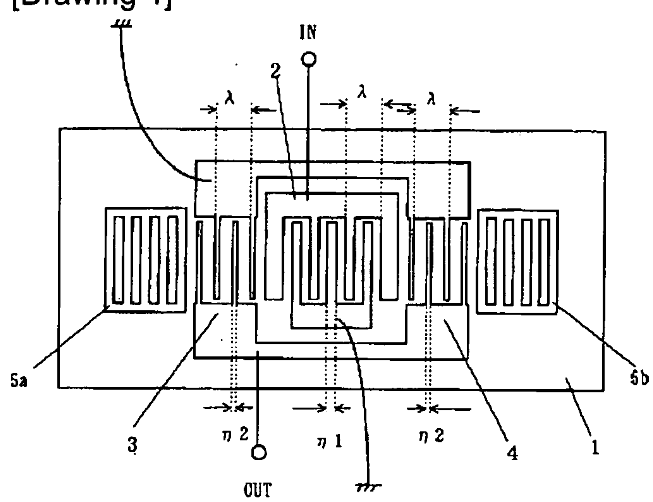
M1, M2 .. Main lobe

P1, P2 .. Attenuation by the side of the RF of a main lobe

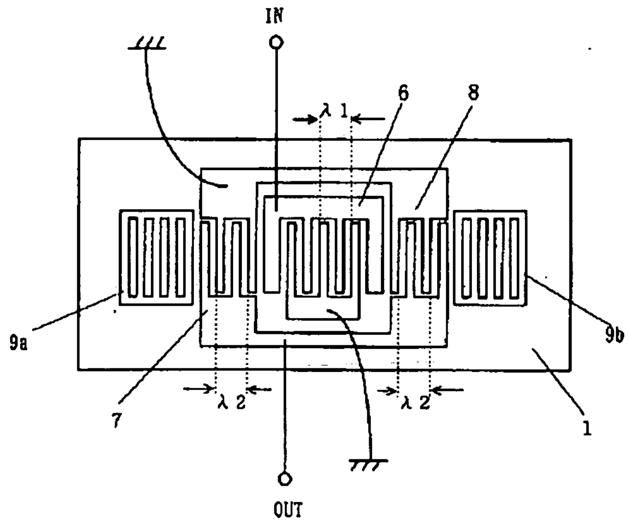
[Translation done.]

DRAWINGS

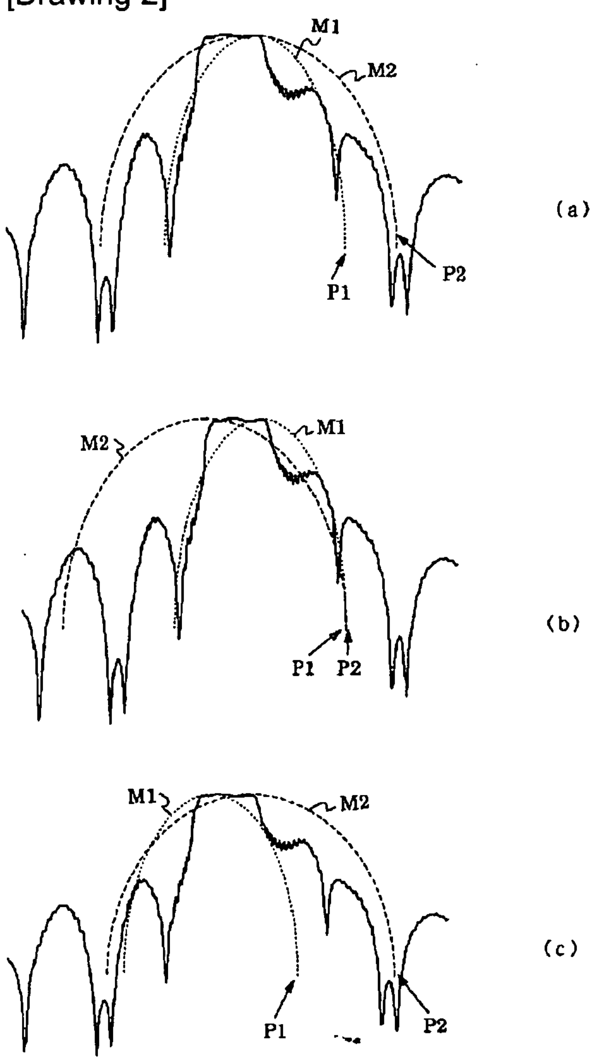
[Drawing 1]



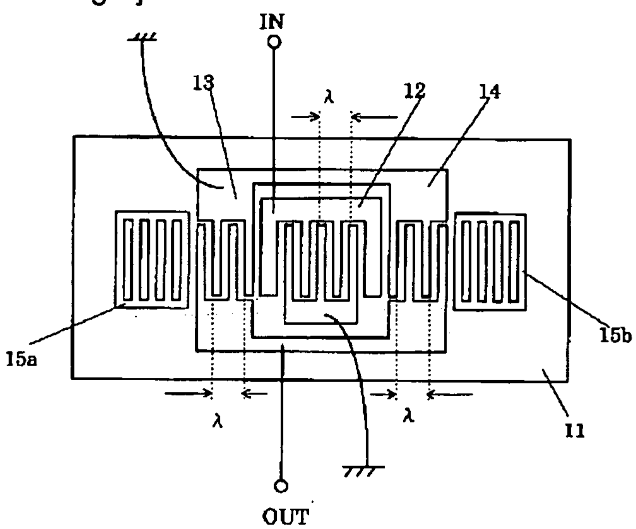
[Drawing 3]



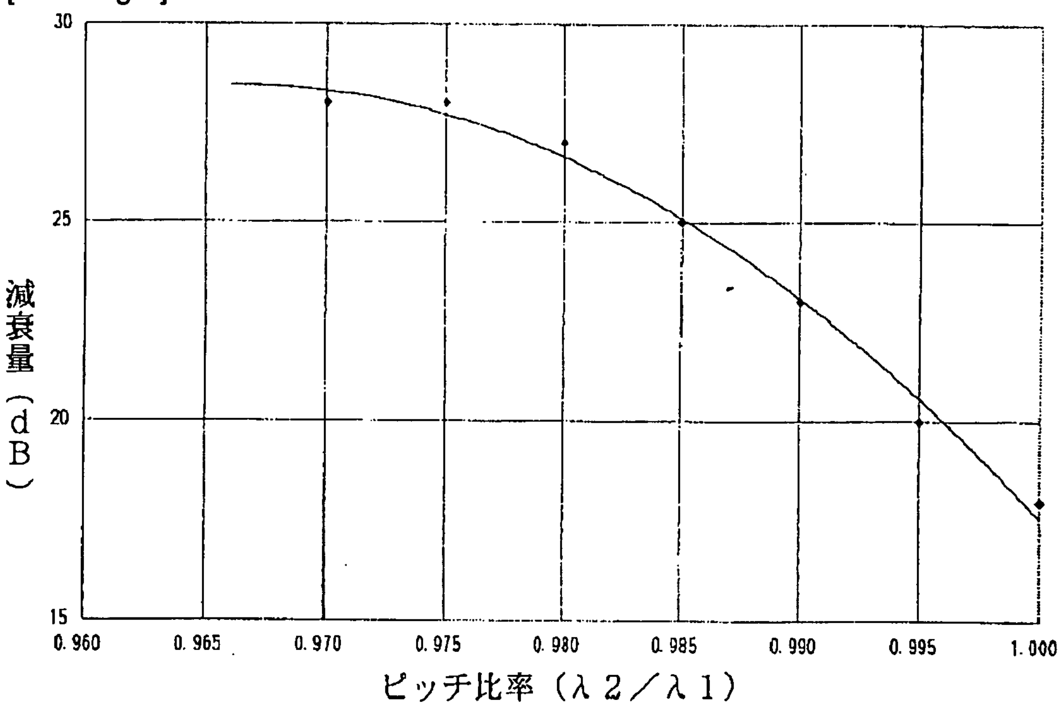
[Drawing 2]



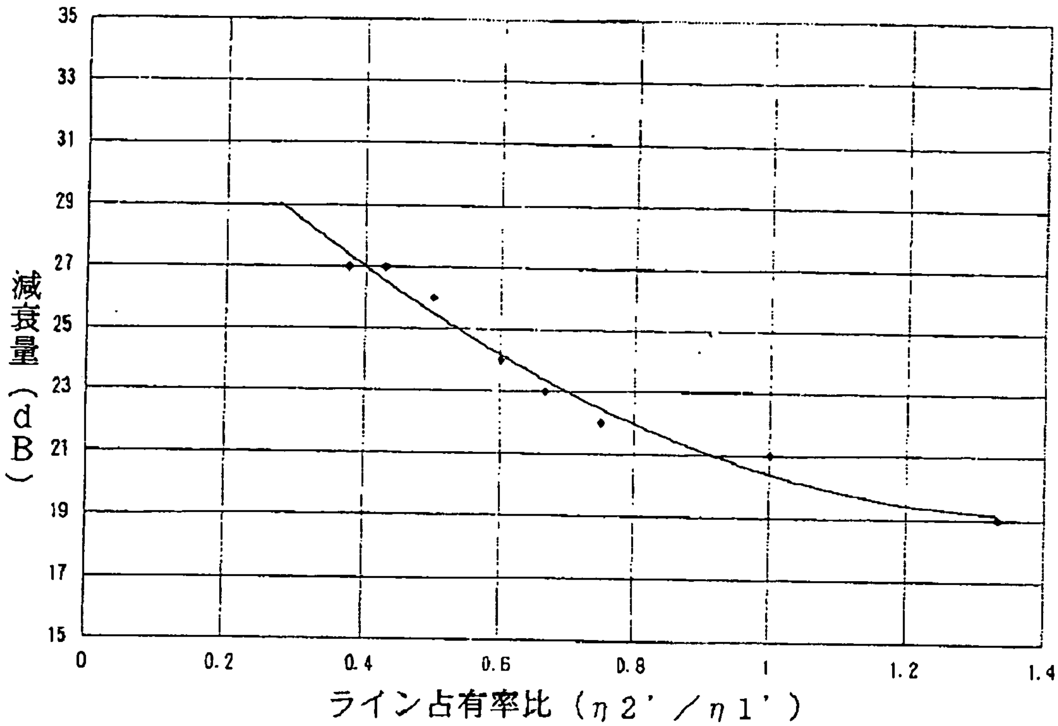
[Drawing 7]



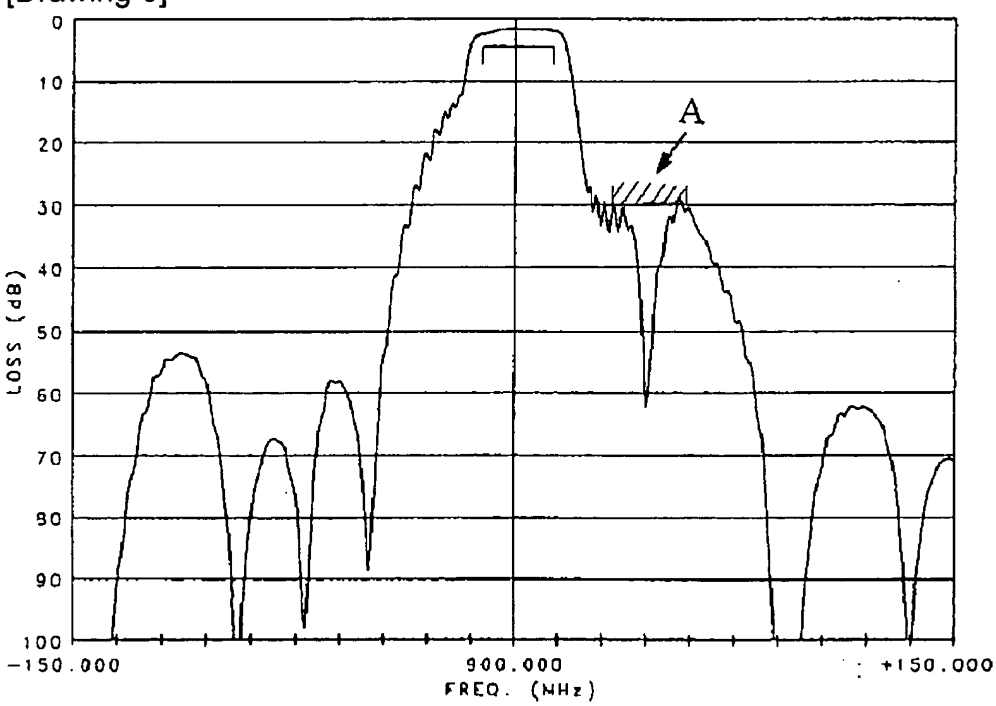
[Drawing 4]



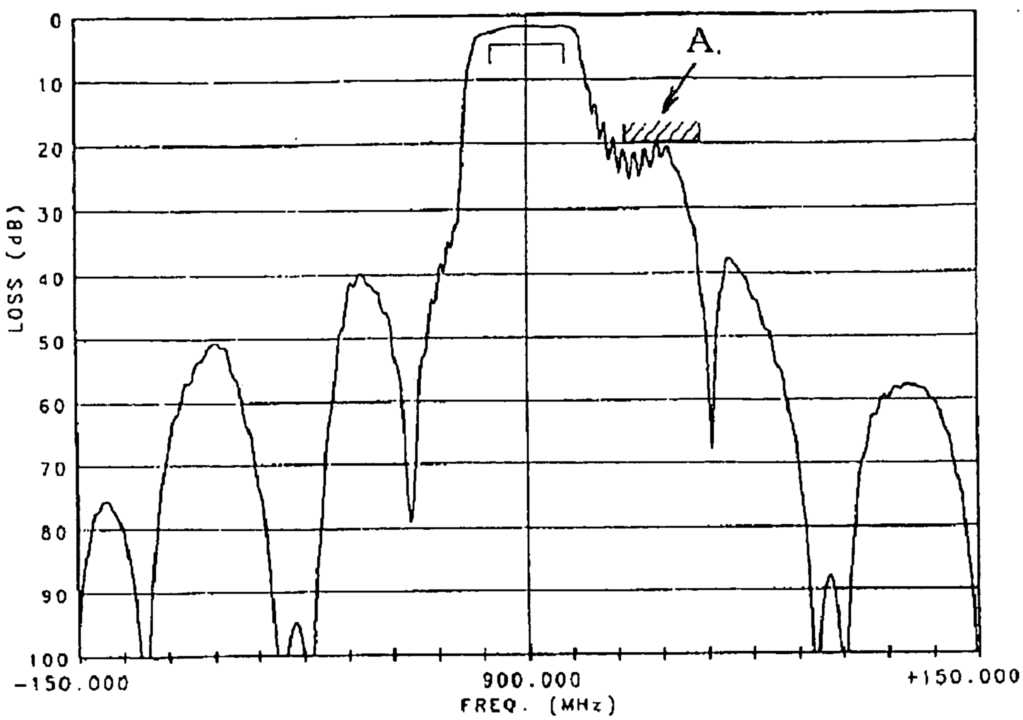
[Drawing 5]



[Drawing 6]



[Drawing 8]



[Translation done.]

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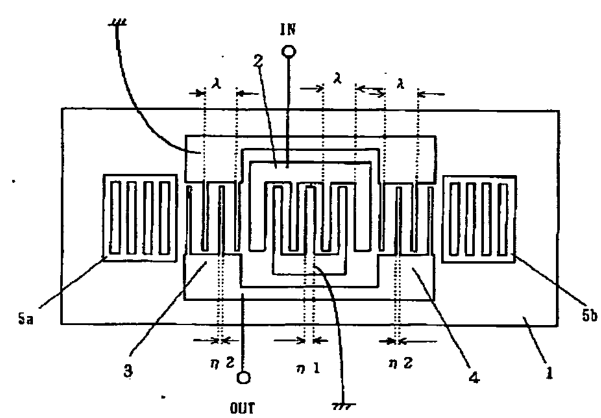
(54)【発明の名称】縦結合二重モードＳＡＷフィルタ

(57)【要約】

【課題】　縦結合二重モードＳＡＷフィルタの通過帯域近傍の高周波側に生じる減衰量の劣化を補償する手段を得る。

【解決手段】　圧電基板上に少なくとも２個のＩＤＴ電極と２個のグレーティング反射器とを用いて構成した縦結合二重モードＳＡＷフィルタにおいて、入力側ＩＤＴ電極の励振周波数と出力側ＩＤＴ電極の励振周波数を異ならせる。



【特許請求の範囲】

【請求項１】　圧電基板上に表面波の伝搬方向に沿って２個以上のＩＤＴ電極と該ＩＤＴ電極の両側にグレーティング反射器とを配置して構成した縦結合二重モードＳＡＷフィルタにおいて、入力側ＩＤＴ電極の励振周波数と出力側ＩＤＴ電極の励振周波数を異ならせることを特徴とする縦結合二重モードＳＡＷフィルタ。

【請求項２】　入力側ＩＤＴ電極の電極指ライン占有率η１'と出力側ＩＤＴ電極のライン占有率η２'を異ならせたことを特徴とする請求項１記載の縦結合二重モードＳＡＷフィルタ。

【請求項３】　入力側ＩＤＴ電極の電極指対数をＮ１、ライン占有率をη１'とし、出力側ＩＤＴ電極の電極指＊＊対数をＮ２、ライン占有率をη２'としたとき、η１'とη２'との比を

Ｎ１＞Ｎ２の場合　　　０．２＜η２'／η１'＜１

Ｎ１＜Ｎ２の場合　　　０．２＜η１'／η２'＜１

とすることを特徴とする請求項１あるいは２記載の縦結合二重モードＳＡＷフィルタ。

【請求項４】　入力側ＩＤＴ電極の電極周期λ１と出力側ＩＤＴ電極の電極周期λ２とを異ならせたことを特徴とする請求項１記載の縦結合二重モードＳＡＷフィルタ。

【請求項５】　入力側ＩＤＴ電極の電極指対数をＮ１、電極周期をλ１とし、出力側ＩＤＴ電極の電極指対数をＮ２、電極周期をλ２としたとき、λ１とλ２との比を

Ｎ１＞Ｎ２の場合　　　０．９６０＜λ２／λ１＜１．０００

Ｎ１＜Ｎ２の場合　　　０．９６０＜λ１／λ２＜１．０００

としたことを特徴とする請求項１あるいは４記載の縦結合二重モードＳＡＷフィルタ。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は縦結合二重モードＳＡＷフィルタに関し、特に通過帯域近傍の高域側の阻止域減衰量を改善した縦結合二重モードＳＡＷフィルタに関する。

【０００２】

【従来の技術】近年、ＳＡＷデバイスは通信分野で広く利用され、高性能、小型、量産性等の優れた特徴を有することから特に携帯電話等に多く用いられている。図７は従来の１次－３次縦結合二重モードＳＡＷフィルタ（以下、二重モードＳＡＷフィルタと称す）の構成を示す電極パターンの模式的平面図であって、圧電基板１１の主面上に表面波の伝搬方向に沿って３つのＩＤＴ電極１２、１３、１４を近接配置すると共に、これらの両側に反射器１５ａ、１５ｂを配設したものである。ＩＤＴ電極１２、１３、１４はそれぞれ互いに間挿し合う複数本の電極指を有する一対のくし形電極により構成され、ＩＤＴ電極１２の一方のくし形電極は入力端子INに接続し、他方のくし形電極は接地する。一方、ＩＤＴ電極１３、１４の一方のくし形電極は互いに連結して出力端子OUTに接続すると共に、他方のくし形電極は互いに連結して接地する。

【０００３】図７に示す二重モードＳＡＷフィルタの動作は、周知のように、ＩＤＴ電極１２、１３、１４によって励起される複数の表面波が反射器１５ａ、１５ｂの間に閉じ込められて、ＩＤＴ電極１２、１３、１４の間で音響結合し、その結果１次と３次の２つの縦共振モードが強勢に励振されるため、適当な終端を施すことによりこれらの２つのモードを利用した二重モードＳＡＷフィルタとして動作する。なお、該二重モードＳＡＷフィルタの通過帯域幅は１次共振モードと３次共振モードとの周波数差で決まることは周知の通りである。

【０００４】図８は、図７に示す２段縦続接続の二重モードＳＡＷフィルタの濾波特性を示したものであって、圧電基板に３６°ＹカットＸ伝搬$LiTaO_3$を用い、入力ＩＤＴ電極１２の電極対数Ｎ１を２０．５対、出力電極１３、１４の電極対数Ｎ２をそれぞれ１１．５対、グレーティング１５ａ、１５ｂの本数をそれぞれ２５０本、アルミニウム合金の電極膜厚を６％λ（λは励起される表面波の波長）とし、フィルタの中心周波数を９００ＭＨｚになるように前記電極のピッチを設定したものであり、比帯域４％と広帯域なバンドパスフィルタを得ることができる。

【０００５】

【発明が解決しようとする課題】しかしながら、図８の濾波特性から明らかなように、１ｄＢの通過帯域幅の中心周波数をf_oとし、二重モードＳＡＷフィルタの周波数領域f_o±（４５±１２．５）ＭＨｚの減衰量は、低周波側のf_o－（４５±１２．５）ＭＨｚでは４０ｄＢ程度得られるのに対して、高周波側のf_o＋（４５±１２．５）ＭＨｚの周波数領域Ａでは２０ｄＢ程度しか得られず、最近のディジタル携帯電話に要求される仕様（２５ｄＢ以上）を満足できないという問題があった。本発明は上記問題を解決するためになされたものであって、広帯域であると共に上記通過帯域近傍の高周波側の阻止域減衰量を改善した二重モードＳＡＷフィルタを提供することを目的とする。

【０００６】

【課題を解決するための手段】上記目的を達成するために本発明に係る縦結合二重モードＳＡＷの請求項１記載の発明は、圧電基板上に表面波の伝搬方向に沿って２個以上のＩＤＴ電極と該ＩＤＴ電極の両側にグレーティング反射器とを配置して構成した縦結合二重モードＳＡＷフィルタにおいて、入力側ＩＤＴ電極の励振周波数と出力側ＩＤＴ電極の励振周波数を異ならせることを特徴とする縦結合二重モードＳＡＷフィルタである。請求項２記載の発明は、入力側ＩＤＴ電極の電極指ライン占有率

η１’と出力側ＩＤＴ電極のライン占有率η２’を異ならせたことを特徴とする請求項１記載の縦結合二重モードＳＡＷフィルタである。請求項３記載の発明は、入力側ＩＤＴ電極の電極指対数をＮ１、ライン占有率をη１’とし、出力側ＩＤＴ電極の電極指対数をＮ２、ライン占有率をη２’としたとき、η１’とη２’との比を

Ｎ１＞Ｎ２の場合　　０．２＜η２’／η１’＜１

Ｎ１＜Ｎ２の場合　　０．２＜η１’／η２’＜１

とすることを特徴とする請求項１あるいは２記載の縦結＊合二重モードＳＡＷフィルタである。請求項４記載の発明は、入力側ＩＤＴ電極の電極周期λ１と出力側ＩＤＴ電極の電極周期λ２を異ならせたことを特徴とする請求項１記載の縦結合二重モードＳＡＷフィルタである。請求項５記載の発明は、入力側ＩＤＴ電極の電極指対数をＮ１、電極周期をλ１とし、出力側ＩＤＴ電極の電極指対数をＮ２、電極周期をλ２としたとき、λ１とλ２との比を

Ｎ１＞Ｎ２の場合　　０．９６０＜λ２／λ１＜１．０００

Ｎ１＜Ｎ２の場合　　０．９６０＜λ１／λ２＜１．０００

としたことを特徴とする請求項１あるいは４記載の縦結合二重モードＳＡＷフィルタである。

【０００７】

【発明の実施の形態】以下本発明を図面に示した実施の形態に基づいて詳細に説明する。図１は本発明に係る二重モードＳＡＷフィルタの構成を示す平面図であって、圧電基板１の主面上に表面波の伝搬方向に沿って３つのＩＤＴ電極２、３、４近接配置すると共に、これらの両側にグレーティング反射器５ａ、５ｂを配設する。ＩＤＴ電極２、３、４はそれぞれ互いに間挿し合う複数本の電極指を有する一対のくし形電極により構成され、ＩＤＴ電極２の一方のくし形電極は入力端子INに接続し、他方のくし形電極は接地する。一方、ＩＤＴ電極３、４の一方のくし形電極は互いに連結して出力端子OUTに接続すると共に、他方のくし形電極は互いに連結して接地する構造とする。

【０００８】本発明の特徴は、ＩＤＴ電極２、３、４の電極周期をほぼ同一とすると共に、ＩＤＴ電極２の電極指幅η１をＩＤＴ電極３、４の電極指幅η２より幅広に設定することにある。図１はＩＤＴ電極２の電極対数Ｎ１をＩＤＴ電極３、４の電極対数Ｎ２より多く設定した例である。

【０００９】正規型ＩＤＴ電極の電極対数をＮ、その電極周期をλ、基準化周波数をΩ（＝（ω－ω_0）／ω_0、ここでω_0＝２πＶ／λ＝２πf_0、Ｖは表面波の速度）とすると、ＩＤＴ電極の周波数特性は、

ｓｉｎ（ＮπΩ）／ｓｉｎ（πΩ）

で表され、減衰極は１／Ｎおきに現れ、その帯域幅は対数Ｎに反比例することが知られている。この周期的に繰り返すＩＤＴ電極の周波数特性を以下、トランスバーサル特性という。二重モードＳＡＷフィルタの通過帯域外の周波数特性は、入出力ＩＤＴ電極２～４のトランスバーサル特性が現れ、阻止域にはそのトランスバーサル特性による周期的な減衰極が現れる。このうちメインローブの高周波側の減衰極を、図８に示すf_0＋（４５±１２．５）ＭＨｚの周波数領域Ａに一致させることができれば、該周波数領域の減衰量の改善がはかられるものと推察される。

【００１０】従来の二重モードＳＡＷフィルタでは図７に示すように入力ＩＤＴ電極１２の電極指対数Ｎ１を出力ＩＤＴ電極１３、１４の電極指対数Ｎ２より多く設定すると共に、入出力ＩＤＴ電極１２、１３、１４の励振周波数をほぼ同一と設定するのが一般的である。従って、トランスバーサル特性による入力ＩＤＴ電極１２のメインローブＭ１、出力ＩＤＴ電極１３、１４のメインローブＭ２は図２（ａ）に示すように、それぞれの帯域幅の中心周波数はほぼ同一となる。ところが、ＩＤＴ電極１２とＩＤＴ電極１３、１４との電極対数をＮ１＞Ｎ２とすることにより、それぞれのメインローブの帯域幅は図２（ａ）に示すように異なる。つまり、メインローブＭ２の帯域幅に比べ、メインローブＭ１の帯域幅は峡帯域となる。ここで、Ｐ１、Ｐ２はそれぞれメインローブＭ１、Ｍ２の高周波側の減衰極を指すものとする。二重モードＳＡＷフィルタの通過帯域は、入出力ＩＤＴ電極１２～１４のメインローブＭ１、Ｍ２内に位置するので、メインローブの減衰極Ｐ１、Ｐ２は周波数領域Ａの外側に現れることになる。そこでメインローブの減衰極Ｐ１、Ｐ２の位置を制御して、改善すべき周波数領域Ａに一致させるための手段を種々検討した。

【００１１】その結果、入出力ＩＤＴ電極の励振周波数を単純に異ならせるだけでは、上記の周波数領域Ａにメインローブの減衰極Ｐ１、Ｐ２を配置することは不可能であることが分かった。この理由は、二重モードＳＡＷフィルタの通過帯域は入出力ＩＤＴ電極１２～１４が呈するトランスバーサル特性のメインローブ内に位置しているが、入力ＩＤＴ電極１２の電極対数Ｎ１を出力ＩＤＴ電極１３、１４のそれぞれの電極対数Ｎ２より多く設定しているために、入力ＩＤＴ電極１２によって形成される帯域幅の狭いメインローブＭ１の帯域幅の内側に形成されることになる。

【００１２】以上の理由で、図２（ｂ）に示すように帯域幅の狭いメインローブＭ１を帯域幅の広いメインローブＭ２より高周波側に配置する手段では周波数領域Ａにメインローブの減衰極Ｐ１、Ｐ２を一致させることができない。そこで、図２（ｃ）に示すように帯域幅の狭いメインローブＭ１を帯域幅の広いメインローブＭ２より低周波側に配置することにより、メインローブＭ１の高周波側に現れる減衰極Ｐ１を二重モードＳＡＷフィルタ

の改善すべき周波数領域Ａに一致させることが可能であることを見出した。

【００１３】まず、ＩＤＴ電極の励振周波数を電極ピッチを変えることにより変化させた場合を検討する。図３はＩＤＴ電極６、７、８のライン占有率を一定として、ＩＤＴ電極６とＩＤＴ電極７、８と電極指ピッチを互いに異ならせることにより、それぞれの励振周波数を変えた二重モードＳＡＷフィルタである。図３の二重モードＳＡＷフィルタを２段縦続接続して、周波数領域Ａにおける減衰量と電極周期比（λ２／λ１）関係をシミュレーションにより求めた結果を図４に示す。図４から明らかなように、通過帯域を良好な状態に維持したまま、周波数領域Ａにおける減衰量が改善できる電極周期比（λ２／λ１）の範囲は、入力電極の電極指対数Ｎ１が出力電極の電極指対数Ｎ２より多い場合には、０．９６＜λ２／λ１＜１．０００であることが判った。

【００１４】上記の結果に基づき、圧電基板に３６°ＹカットＸ伝搬$LiTaO_3$を用い、入力ＩＤＴ電極６の電極指対数Ｎ１を２２．５対、出力ＩＤＴ電極７、８の電極指対数Ｎ２をそれぞれ１２．５対、グレーティング反射器９ａ、９ｂの本数を２５０本、アルミニウム合金の電極膜厚を６％λ、入力ＩＤＴ電極周期λ１対する出力ＩＤＴ電極７、８の電極周期λ２の比λ２／λ１を０．９８０に設定した二重モードＳＡＷフィルタを構成すると、その濾波特性はf_o+（４５±１２．５）ＭＨｚの周波数領域で減衰量が約８ｄＢ改善できることが分かった。ところが、実際には上記電極周期の差はごく僅かであり、現在のフォトリソグラフィ技術による製造誤差により、その効果を十分に享受することができない場合がある。

【００１５】そこで、ＩＤＴを同一の電極周期で励振周波数を変える手段を検討することとした。第１にＩＤＴ電極の電極膜厚を変化させる方法、第２にＩＤＴ電極指のライン占有率（ライン幅／（ライン幅＋スペース幅））を変化させる方法がある。前者では、同一の圧電基板上で１～２μｍの空間を挟んで隣接するＩＤＴ電極２と３、４との膜厚を正確に制御することが必要となるが、製造工程が複雑となるのはもちろん、現在の技術では製造バラツキが大きくあまり実用的ではない。そこで、入出力ＩＤＴ電極の電極周期を変えずに、励振周波数を変化させる手段として、図１に示すようにＩＤＴ電極２のライン幅η１とＩＤＴ電極３、４のライン幅η２とを互いに異ならせる方法を検討した。同一電極周期であるためライン幅η１、η２の比はそれぞれのライン占有率η１’、η２’の比と等しい。

【００１６】ＩＤＴ電極２、３、４の電極周期を同一にし、入力ＩＤＴ電極２のライン占有率η１’と出力ＩＤＴ電極３、４のライン占有率η２’を互いに異ならせることにより、それぞれの励振周波数を変えて二重モードＳＡＷフィルタを構成した例が図１である。図５は、図１に示した二重モードＳＡＷフィルタを２段縦続接続したフィルタの周波数領域Ａ（f_o+（４５±１２．５）ＭＨｚ）において、その減衰量とライン占有率比（η２’／η１’）との関係をシミュレーションにより求めた結果である。これは通過帯域を良好な状態に維持したまま、図８における周波数領域Ａにおいて減衰量が改善できるライン占有率の比η２’／η１’は、入力電極の電極指対数Ｎ１が出力電極の電極指対数Ｎ２より多い場合には、０．２＜η２’／η１’＜１と設定すべきであることを示している。

【００１７】図６は上記の検討結果に基づき構成したフィルタの濾波特性を示す図であって、圧電基板に３６°ＹカットＸ伝搬$LiTaO_3$を用い、入力ＩＤＴ電極２の電極指対数Ｎ１を２０．５対、出力ＩＤＴ電極３、４の電極指対数Ｎ２をそれぞれ１１．５対、グレーティング反射器５ａ、５ｂの本数を２５０本、アルミニウム合金の電極膜厚を６％λ、入力ＩＤＴ電極のライン占有率η１’に対する出力ＩＤＴ電極のライン占有率η２’の比η２’／η１’を０．４３に設定したと場合の特性である。なお電極指ピッチはフィルタの中心周波数が９００ＭＨｚになるように設定した。

【００１８】図６から明らかなように通過帯域近傍の高周波側（周波数領域Ａ）の減衰量が、図８に示した従来の二重モードＳＡＷフィルタの減衰量に比べて１０ｄＢ程度改善されていることが分かる。この改善より通過帯域近傍の減衰量を急峻にする必要がある携帯電話用ＲＦフィルタの要求を十分に満たすことができるようになった。

【００１９】図１の説明では、入力ＩＤＴ電極２の電極指対数Ｎ１が出力ＩＤＴ電極３、４の電極指対数Ｎ２より多い場合の例を取り上げたが、逆に入力ＩＤＴ電極２の電極指対数Ｎ１が出力ＩＤＴ電極３、４の電極指対数Ｎ２より少ない場合を検討すると、ライン占有率を変えて周波数領域Ａにおける減衰量を改善する場合、ライン占有率比は０．２＜η１’／η２’＜１とすればよいことが確認できた。

【００２０】また、図５の例では入力ＩＤＴ電極６の電極指対数Ｎ１が出力ＩＤＴ電極７、８の電極指対数Ｎ２より多い場合を説明したが、逆に入力ＩＤＴ電極６の電極指対数Ｎ１が出力ＩＤＴ電極７、８の電極指対数Ｎ２より少ない場合を検討すると、電極周期を変えて周波数領域Ａの減衰量を改善するには、電極周期比を０．９６＜λ１／λ２＜１．０００とすればよいことを確認した。

【００２１】なお、以上の説明では３個のＩＤＴ電極を用いた１次－３次縦結合二重モードＳＡＷフィルタに説明したが、本発明はこれのみに限定されるものではなく２個以上のＩＤＴ電極を持つ二重モードＳＡＷフィルタであれば適用可能であることは云うまでもない。

【００２２】さらに、以上本発明の説明で圧電基板に３

６°ＹカットＸ伝搬ＬｉＴａＯ３を用いた例を示したが、本発明はこれのみに限定されるものではなく、どのような圧電基板を用いた縦結合二重モードＳＡＷフィルタにも適用可能である。例えば４５°ＸカットＺ伝搬Ｌｉ$_2$Ｂ$_4$Ｏ$_7$、ＳＴカット水晶、４２°ＹカットＸ伝搬ＬｉＴａＯ$_3$あるいは６４°ＹカットＸ伝搬ＬｉＮｂＯ$_3$等の圧電材料にも適用できることは云うまでもない。

【００２３】

【発明の効果】本発明は、以上説明したように構成したので、縦結合二重モードＳＡＷフィルタにおいて通過帯域の近傍の高周波側の減衰量を１０ｄＢ程度改善することができるようになり、本発明の二重モードＳＡＷフィルタを携帯電話等のＲＦフィルタに用いればその性能を改善する上で優れた効果を表す。

【図面の簡単な説明】

【図１】本発明に係る１次−３次縦結合二重モードＳＡＷフィルタの電極構成を示す平面図である。

【図２】（ａ）、（ｂ）、（ｃ）は入出力ＩＤＴ電極の呈するメインローブの周波数とフィルタ特性の関係を説明する図である。

【図３】本発明に係る１次−３次縦結合二重モードＳＡＷフィルタの実施例で、電極周期を変えて構成したフィルタの平面図である。

【図４】ＩＤＴ電極のピッチ比と通過帯域近傍の高周波側の減衰量との関係を示す図である。

【図５】ライン占有率比λ２’／λ１’と二重モードＳＡＷフィルタの通過域近傍の減衰量との関係を示す図である：

【図６】本発明に係る二重モードＳＡＷフィルタをシミュレーションにより求めた濾波特性である。

【図７】従来の１次−３次縦結合二重モードＳＡＷフィルタの電極構成を示す平面図である。

【図８】従来の１次−３次縦結合二重モードＳＡＷフィルタのフィルタ特性を示す図である。

【符号の説明】

１・・圧電基板

３、４、６、７、８・・ＩＤＴ電極

５ａ、５ｂ、９ａ、９ｂ・・グレーティング反射器

λ１、λ２・・ＩＤＴ電極周期

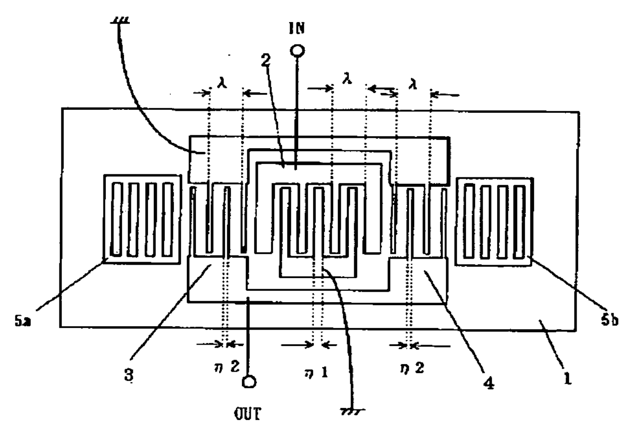
η１、η２・・ライン幅

η１’、η２’・・ライン占有率

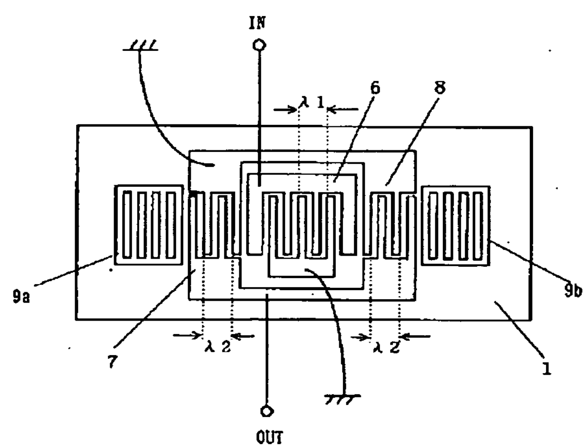
Ｍ１、Ｍ２・・メインローブ

Ｐ１、Ｐ２・・メインローブの高周波側の減衰

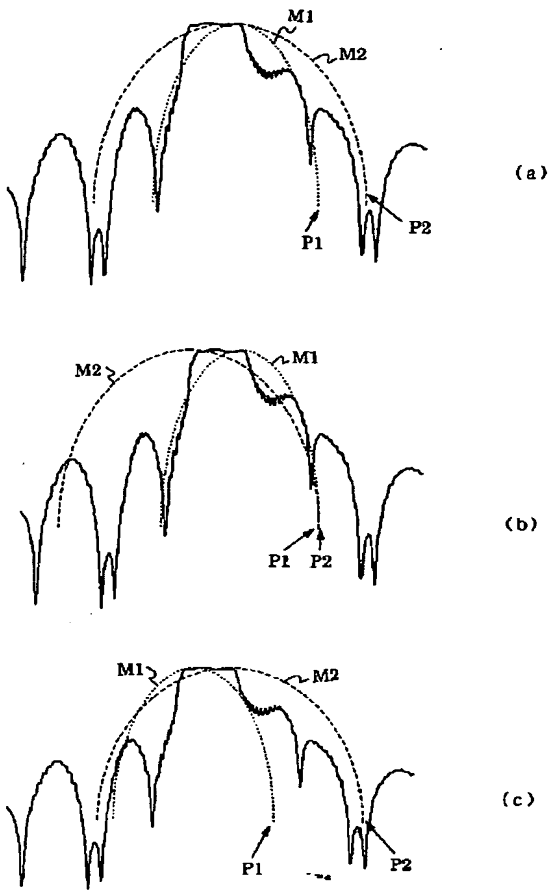
【図１】



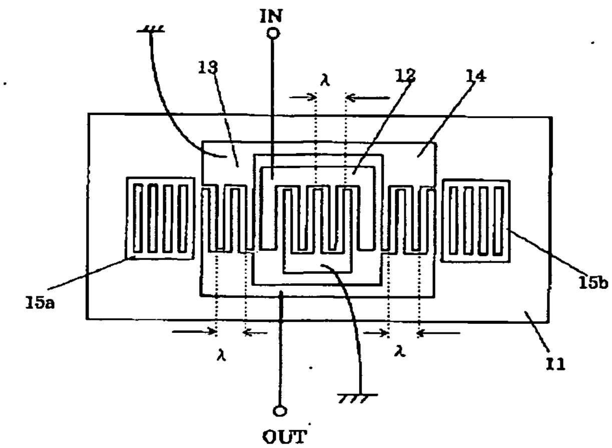
【図３】



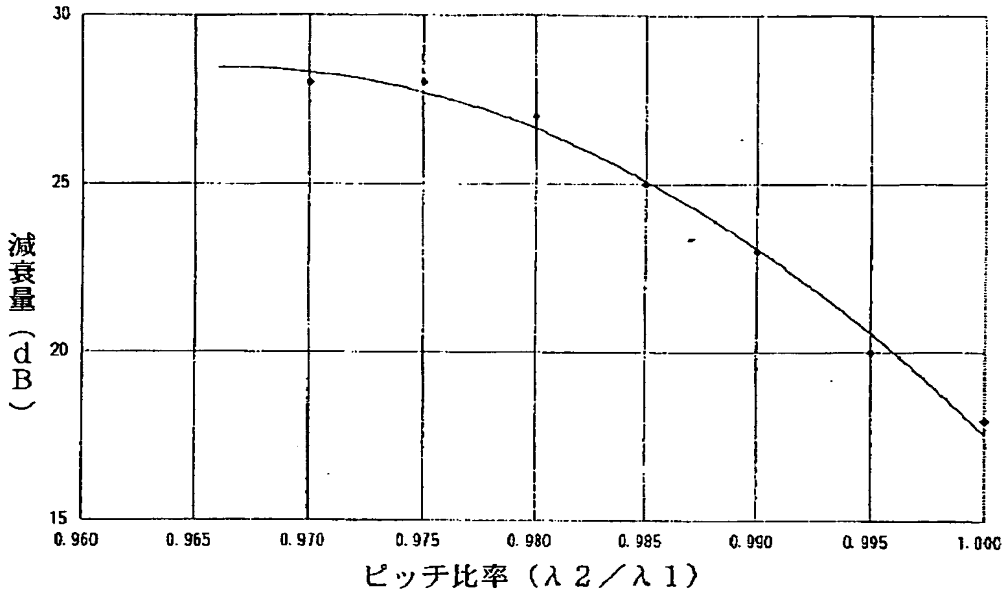
【図２】



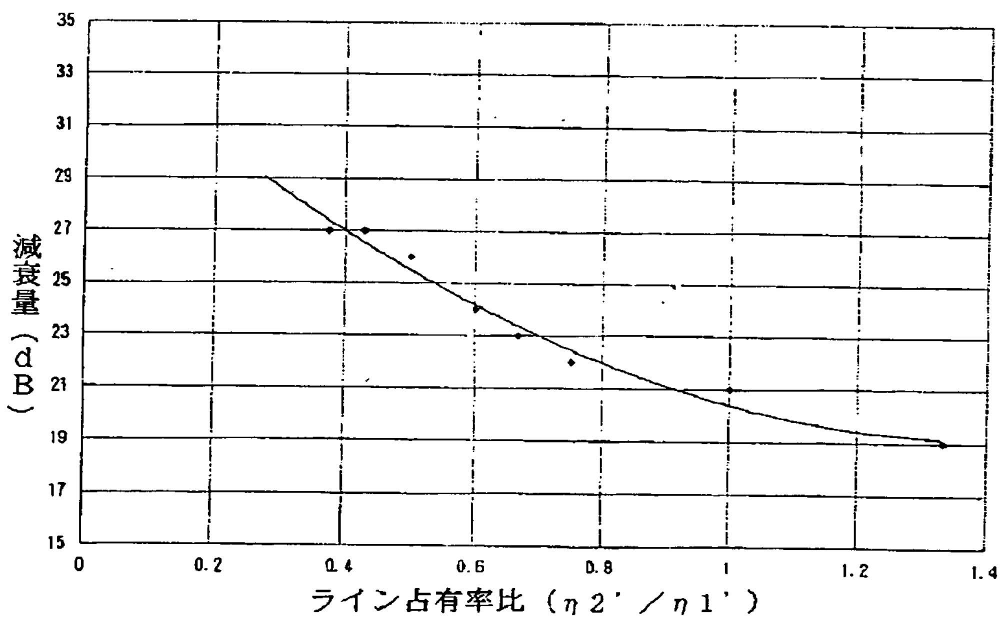
【図７】



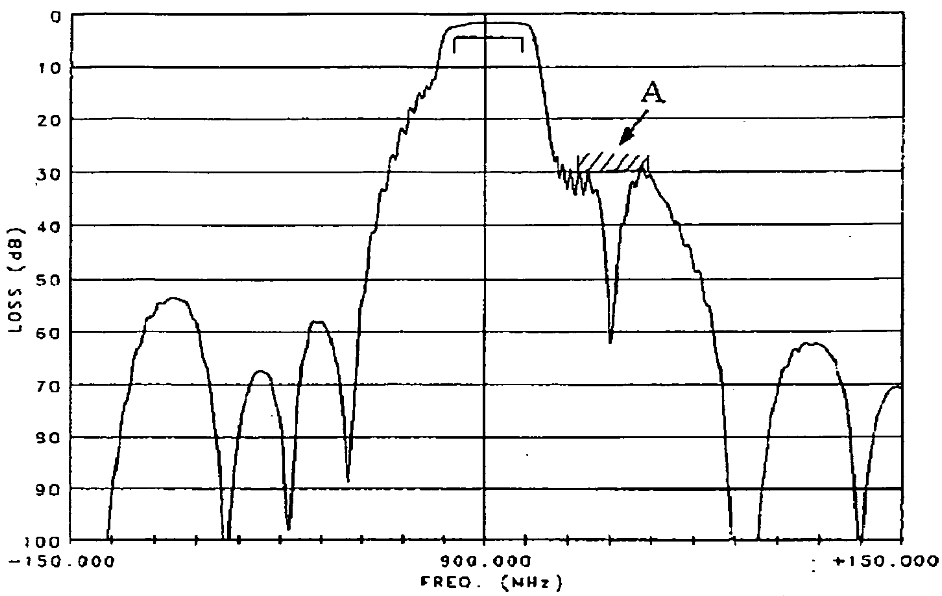
【図４】


30
25
20
15
減衰量（dB）
0.960
0.965
0.970
0.975
0.980
0.985
0.990
0.995
1.000
ピッチ比率（λ２／λ１）

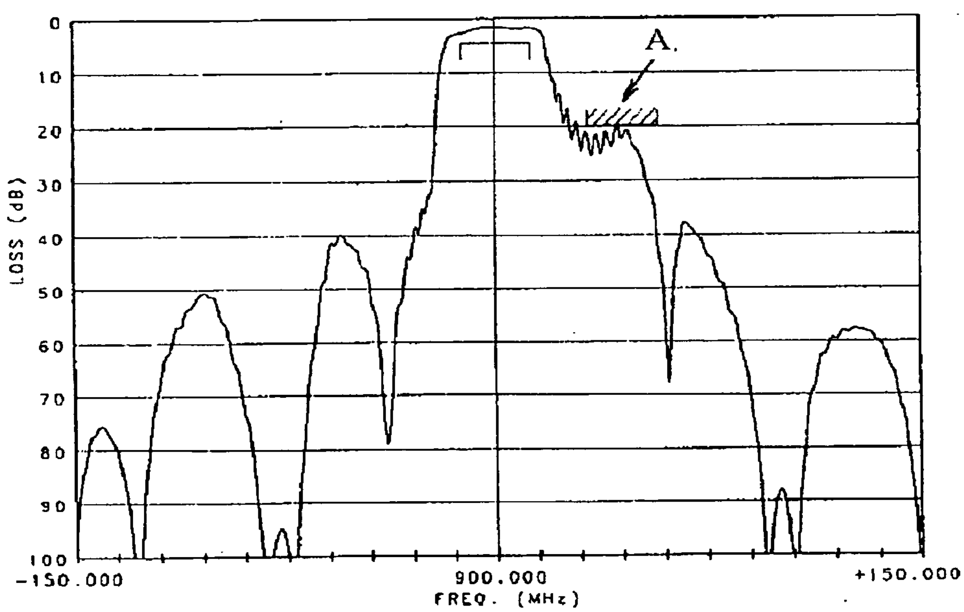
【図５】


35
33
31
29
27
25
23
21
19
17
15
減衰量（dB）
0
0.2
0.4
0.6
0.8
1
1.2
1.4
ライン占有率比（η２'／η１'）

【図６】


A
0
10
20
30
40
50
60
70
80
90
100
LOSS (dB)
-150.000
900.000
+150.000
FREQ. (MHz)

【図８】


A.
0
10
20
30
40
50
60
70
80
90
100
LOSS (dB)
-150.000
900.000
+150.000
FREQ. (MHz)